

**SHUSAKU YAMAMOTO**

(Translation)

**Japanese Laid-open Publication No. 63-279228**

Publication date: November 16, 1988

Application number: 62-112588

Filing date: May 11, 1987

Applicant: Oki Electric Industry Co., Ltd

**SPECIFICATION**

1. Title of the Invention      LIQUID      CRYSTAL      DISPLAY  
APPARATUS

**2. Claims**

(1) An active-matrix-drive-type liquid crystal display apparatus comprising a pixel electrode substrate having provided thereon a switching element; and a common electrode substrate, characterized in that the liquid crystal display apparatus is configured by:

    providing an insulating layer having a flat surface, on the pixel electrode substrate surface; and

    providing a pixel electrode on the flat surface of the insulating layer such that the pixel electrode is connected to the switching element through a contact hole provided in the insulating layer.

(2) The liquid crystal display apparatus according to claim 1, characterized in that the liquid crystal display apparatus is configured by providing an electrical separation region for the pixel electrode, in a region above a data electrode of the switching element.

**SHUSAKU YAMAMOTO****3. Detailed Description of the Invention****(Industrial Application Field)**

The present invention relates to a liquid crystal display apparatus, and more particularly, to a liquid crystal display apparatus capable of preventing degradation of display quality caused by a defect in liquid crystal alignment.

**(Prior Art)**

A liquid crystal display apparatus is expected as one of flat panel displays that are a substitute for a CRT. Furthermore, the liquid crystal display apparatus has extremely low power consumption over other types of display apparatuses using light emission, and thus is suitable for a battery-driven compact display apparatus, e.g., an ultra-compact television set; therefore, studies have been actively conducted in this field. Also, since by combining a liquid crystal panel and color filters, vivid color display is enabled, studies on color display have been conducted and some of them have been put to practical use.

For a method of driving such a liquid crystal display apparatus, various methods are considered but a method having been performed in recent years can be said to be an active-matrix drive method.

A liquid crystal display apparatus of a type suitable for such an active-matrix drive method is well-known. With reference to FIGS. 3 to 5, the general structure of a conventional liquid crystal display apparatus of this type will be briefly described below.

FIG. 3 is a partial plan view mainly showing a disposition

**SHUSAKU YAMAMOTO**

relationship between components on a side of a substrate where switching elements are provided (which may be referred to also as a pixel electrode substrate) of a conventional active-matrix-type liquid crystal display apparatus. Note that in this case, it shows using an example in which the switching elements are thin-film transistors (TFTs).

In FIG. 3, 11 indicates a source electrode serving as a data electrode and 13 indicates a gate electrode serving as a scanning electrode. These electrodes are formed in a matrix form on a suitable substrate, such as a glass substrate, for example. Also, in a region where these two electrodes intersect each other, a TFT 15 is formed and in the drawing the one indicated by 17 is a drain electrode of the TFT 15. To the drain electrode 17 is connected a pixel electrode 19 (shown with hatched lines in the drawing).

FIG. 4 is a cross-sectional view schematically showing the pixel electrode substrate shown in FIG. 3, taken along line I-I shown in FIG. 3. Note that in order to avoid the drawing from becoming complicated, hatching indicating a cross-section is partly omitted.

In FIG. 4, 21 indicates a glass substrate, for example, serving as a substrate. 23 indicates a gate insulating film, 25 indicates an amorphous Si film, and 27 indicates a protective film.

FIG. 5 is a cross-sectional view schematically showing a conventional liquid crystal display apparatus configured by using the pixel electrode substrate described using FIGS. 3 and 4 and an other substrate having a common electrode (which may be referred to also as a common electrode substrate) which

**SHUSAKU YAMAMOTO**

is separately prepared. Note that the liquid crystal display apparatus shown in FIG. 5 is an example of a color display liquid crystal display apparatus. Also, in order to avoid the drawing from becoming complicated, hatching indicating a cross-section is partly omitted.

In FIG. 5, 31 indicates a second substrate. On the substrate 31 are sequentially provided color display color filters 33 and a common electrode 35 from the substrate side. Also, the one indicated by 37 in the drawing is an alignment film and is formed on each of side of the pixel electrode substrate 21 and the common electrode substrate 31 that face each other. A liquid crystal 39 is filled between the substrates 21 and 31.

In the conventional liquid crystal display apparatus, a region where a TFT 15, a scanning electrode (gate electrode) 13, and a data electrode (source electrode) 15 are formed protrudes from a substrate surface and thus a protrusion portion 41 is generated. Also, though a common electrode of a monochrome display liquid crystal display apparatus does not encounter a problem, when, as shown in FIG. 5, the color filters 33 are used on the liquid crystal injection side of the common electrode substrate, a recess portion 43 is generated between adjacent color filters. As such, in the conventional liquid crystal display apparatus, steps of the order of 1 to 2  $\mu\text{m}$  are continuously and regularly present on a liquid crystal filled region side surface(s) of one or both of the two substrates facing each other.

Also, as is clear from FIG. 3, in the conventional liquid crystal display apparatus, in order to prevent a pixel electrode

**SHUSAKU YAMAMOTO**

19 from being short-circuited to a source electrode 11 and a gate electrode 13, the pixel electrode needs to be distanced from these electrodes.

Meanwhile, in a conventional active-matrix-type liquid crystal display apparatus such as that described above, some of liquid crystal molecules being aligned in a direction that is not a desired alignment direction (hereinafter, this is referred to as a domain phenomenon) occurs for such reasons as those described later, and due to this, degradation of display quality occurs.

One of the causes of such a domain phenomenon can be said to be a step, such as that described above, present on a substrate. For example, it is assumed that a TFT portion forms a step protruding from a substrate surface by the order of  $2\mu\text{m}$ . Since, though it varies depending on the type of liquid crystal display apparatus, the distance between substrates facing each other is only on the order of  $10\mu\text{m}$  at the widest, when there are steps of the order of  $2\mu\text{m}$  on a substrate, as described above, the dimensions of a liquid crystal filling gap consequently varies between a portion where there is a step and a portion where there is no step. The alignment manners of liquid crystal molecules in such two portions are considered to be different from each other, and due to this, a domain phenomenon occurs.

Another cause of a domain phenomenon is considered to be a bend of an electric line of force. This will be described with reference to FIG. 6.

In an active-matrix-type liquid crystal display apparatus, multiple gate electrodes are sequentially selected and a data signal is applied to each of source electrodes of

**SHUSAKU YAMAMOTO**

multiple pixels belonging to a selected gate electrode. Now, the case is considered in which multiple pixels belonging to a certain gate electrode are turned on every other pixel and the other pixels are turned off. FIG. 6 is a diagram schematically showing the state of electric lines of force for the case of driving the conventional liquid crystal display apparatus in the above-described manner, and showing the case in which the pixel electrodes 19 have a positive electric potential relative to a common electrode 37 and a voltage is applied to the pixel electrodes 19. Between a pixel electrode of a TFT being driven and the common electrode, fundamentally, electric lines of force proceeding to the common electrode 37 from the pixel electrode 19 are supposed to be generated; however, even between a TFT being driven and a pixel electrode of a TFT not being driven, an unwanted electric line of force (a bend of an electric line of force shown by 41 in FIG. 6) is considered to be generated. Since the alignment direction of liquid crystal molecules in a region where this unwanted electric line of force is generated is different from the alignment direction in a region where normal electric lines of force are generated, a domain phenomenon is considered to be caused also by this. Such an unwanted electric line of force is also generated in end-portion regions of pixel electrodes in an off state arranged along a data electrode to which an on signal is being applied.

Such a domain phenomenon is seen as a problem and studies are conducted to solve the problem. For a document showing the outcome of the studies, there is, for example, Japanese Patent Application Laid-Open No. 60-243633. According to this publication, in order that after a domain phenomenon occurs

**SHUSAKU YAMAMOTO**

the domain phenomenon is rapidly eliminated, a spacing between a source electrode of a TFT and a side of a pixel electrode is made as linear as possible. Furthermore, in the case of a color display liquid crystal display apparatus, a spacing created between adjacent color filters is aligned so as to face a spacing between the above-described source electrode and a pixel electrode on the side close to the source electrode and not driven by the source electrode.

(Problems to be Solved by the Invention)

However, making a spacing between a source electrode and a pixel electrode as linear as possible, as described above, impairs the flexibility of a pixel arrangement of a liquid crystal display apparatus. Also, aligning the spacings such that they precisely face each other requires more precise alignment and thus is not desirable in view of a fabrication process. Also, since no measures are taken against a domain phenomenon in a portion where an electric line of force bends (a portion shown by 41 in FIG. 6), due to a defect in the alignment of liquid crystal molecules in this portion, display quality is degraded.

The present invention is made in view of problems such as those described above and an object of the present invention is therefore to provide a liquid crystal display apparatus in which a domain phenomenon is less likely to occur and even when a domain phenomenon occurs the domain phenomenon is hard to be visually identified.

(Means for Solving the Problems)

In order to attain the object, according to the present invention, an active-matrix-drive-type liquid crystal display

**SHUSAKU YAMAMOTO**

apparatus comprising a pixel electrode substrate having provided thereon a switching element; and a common electrode substrate, is characterized in that the liquid crystal display apparatus is configured by: providing an insulating layer having a flat surface, on the above-described pixel electrode substrate surface; and providing a pixel electrode on the above-described flat surface of the insulating layer such that the pixel electrode is connected to the above-described switching element through a contact hole provided in the insulating layer.

In implementing the invention, it is preferable that an electrical separation region for the above-described pixel electrode be provided in a region above a data electrode of the above-described switching element.

Note that when a liquid crystal display apparatus is a color displayable liquid crystal display apparatus and has color filters on a common electrode substrate, it is preferable that an insulating layer that planarizes protrusions and recesses formed between the color filters and a substrate surface be provided on the color filters of the common electrode substrate and a common electrode be provided on the insulating layer.

(Functions)

According to such a configuration, protrusions and recesses mainly formed of switching elements, scanning electrodes of the switching elements, data electrodes of the switching elements, and a pixel electrode substrate surface can be covered by an insulating layer having a flat surface. Hence, a liquid crystal filling gap between a pixel electrode substrate and a common electrode substrate has substantially uniform dimensions at any portion between the two substrates,



**SHUSAKU YAMAMOTO**

and thus, various conditions for aligning liquid crystal molecules are also uniform. Accordingly, the occurrence of a domain phenomenon caused by a step can be prevented.

Also, since a switching element and the scanning and data electrodes thereof are covered by an insulating layer, a pixel electrode to be provided on the insulating layer can be formed all the way above a region where the switching element and the two electrodes are formed. Accordingly, a separation region for electrically separating adjacent pixel electrodes can be provided in a region above a scanning electrode or a region above a data electrode.

In a preferred example of the present invention, an electrical separation region between adjacent pixel electrodes and in a direction parallel to a stripe direction of a data electrode of a switching element is provided within a region on an insulating layer portion above the data electrode. Data electrodes and scanning electrodes are generally formed of light-shielding metal thin films. By doing so, an electrical separation region between pixel electrodes which is parallel to data electrodes in which a domain phenomenon due to a bend of an electric line of force is likely to occur, can be covered by these light-shielding metals and thus the domain phenomenon is made unaware to a person viewing the display apparatus.

(Embodiments)

An embodiment of an active-matrix-type liquid crystal display apparatus of the present invention will be described below with reference to FIGS. 1 and 2. Note that it is to be understood that the drawings used in the following description are merely schematically shown to the extent that the present

**SHUSAKU YAMAMOTO**

invention can be understood; therefore, the present invention is not limited to only these exemplary drawings. Also, in the drawings, common components are denoted by the same numerals. Furthermore, the same components as those in the conventional example are denoted by the same numerals as the conventional ones.

Configuration of a liquid crystal display apparatus

FIG. 1(A) is a partial plan view mainly showing a disposition relationship between components on a side of a substrate, where switching elements are provided (pixel electrode substrate), of an active-matrix-type liquid crystal display apparatus of the present invention. Note that in this case, description is made using an example in which the switching elements are thin-film transistors (TFTs).

In FIG. 1(A), 11 indicates a source electrode serving as a data electrode and 13 indicates a gate electrode serving as a scanning electrode. These electrodes are formed in a matrix form on a suitable substrate, such as a glass substrate, for example. Also, in a region where these two electrodes intersect each other, a TFT 15 is formed and in the drawing the one indicated by 17 is a drain electrode of the TFT 15.

Also, though not shown in FIG. 1(A) (description will be made later using FIG. 1(B)), the liquid crystal display apparatus of the present invention includes, on the pixel electrode substrate, an insulating layer having a flat surface and covering protrusions and recesses which are mainly formed of the source electrodes 11, the gate electrodes 13, the TFTs 15 and a substrate surface, and includes pixel electrodes 51

**SHUSAKU YAMAMOTO**

(shown with hatched lines in FIG. 1(A)) on the insulating layer. Then, the pixel electrodes 51 are connected to their corresponding drain electrodes 17 beneath the insulating film, through their corresponding contact holes 53 provided in the insulating layer. Also, using the fact that such an insulating layer is provided, the pixel electrodes 51 in the case of the present embodiment are formed in the following manner.

An electrical separation region 55 between adjacent pixel electrodes 51 among pixel electrodes 51 arranged linearly along a stripe direction of gate electrodes 13 and in a direction parallel to a stripe direction of source electrodes, is formed in a region above a source electrode 11 so as to be included in a formation region of the source electrode. Thus, a pixel electrode in this case is also present above a region where a TFT 15 is formed.

FIG. 1(B) is a cross-sectional view schematically showing the pixel electrode substrate shown in FIG. 1(A), taken along line II-II shown in FIG. 1(A). Note that in order to avoid the drawing from becoming complicated, hatching indicating a cross-section is partly omitted.

In FIG. 1(B), 21 indicates a glass substrate, for example, serving as a substrate. 23 indicates a gate insulating film and 25 indicates an amorphous Si film. 57 indicates an insulating layer, which is already described, for planarizing protrusions and recesses which are mainly formed of the source electrodes 11, the gate electrodes 13, the TFTs 15, and the substrate surface, and a contact hole 53 is formed in a region of the insulating layer 57 that is above a drain electrode 17.

As can also be understood from FIG. 1(B), since the

**SHUSAKU YAMAMOTO**

insulating layer 57 is provided, an electrical separation region 55 between pixel electrodes can be formed above a source electrode. Due to this, even when display data of a certain data electrode among multiple source electrodes (data electrodes), into which display data is always written, becomes a signal continuously indicating a high level and a domain phenomenon occurs for a long period of time between such a data electrode and a pixel electrode in an off state along the data electrode, the domain phenomenon is shielded by the source electrode and thus can be made unaware to a person viewing the liquid crystal display apparatus.

By configuring a liquid crystal display apparatus using such a pixel electrode substrate of the present invention and a conventional common electrode substrate, when the liquid crystal display apparatus is a monochrome display liquid crystal display apparatus, a domain phenomenon caused by a step does not occur at all. Furthermore, regardless of color display or monochrome display, since a domain phenomenon caused by a bend of an electric line of force is shielded by a gate electrode, a person viewing the liquid crystal display apparatus from the pixel electrode substrate side is never aware of the domain phenomenon.

Also, a liquid crystal display apparatus that is a color display liquid crystal display apparatus and uses a conventional common electrode substrate having provided thereon color filters, as shown in FIG. 5, and a pixel electrode substrate of the present invention, has no steps on the pixel electrode substrate side and thus has better display quality over conventional ones. Note that to obtain further better display

**SHUSAKU YAMAMOTO**

in a color display liquid crystal display apparatus having such a configuration, it is preferable that a common electrode substrate be structured as shown in a cross-sectional view in FIG. 2.

In FIG. 2, 31 indicates a glass substrate. On the glass substrate 31, color filters 33 are provided. Also, the common electrode substrate according to the present invention includes, on the glass substrate 31 including the color filters 33, an insulating layer 61 having a flat surface and covering steps mainly formed of the color filters 33 and a surface of the substrate 31 to planarize the steps, and includes a common electrode 37 provided on the insulating layer 61.

In a color display liquid crystal display apparatus of the present invention which is formed by filling a liquid crystal between a pixel electrode substrate, such as that shown in FIGS. 1(A) and 1(B), and a common electrode substrate, such as that shown in FIG. 2, a domain phenomenon caused by a step does not occur at all; moreover, even when a domain phenomenon occurs due to a step at the portion of a contact hole 53 or a bend of an electric line of force in an electrical separation region 55 between pixel electrodes, this is shielded by source and drain electrodes and thus a person viewing the liquid crystal display apparatus from the pixel electrode substrate side is never aware of the domain phenomenon.

Fabrication method of a liquid crystal display apparatus

Next, for further understanding of a liquid crystal display apparatus of the present invention, with reference to FIGS. 1(B) and 2, an example of a fabrication method of a liquid

**SHUSAKU YAMAMOTO**

crystal display apparatus of an embodiment of the present invention will be described. It is to be understood that the materials, forming methods, numerical conditions, etc., described below are merely an example and thus the present invention is not limited to such materials, forming methods, and numerical conditions.

Using a normal thin-film formation technique, a TFT 15 serving as a switching element and a scanning electrode 13 and a data electrode 11 thereof are formed on a glass substrate 21. For this process, a conventional fabrication method of an active-matrix-type liquid crystal display apparatus can be used.

Then, on the glass substrate 21 on which the TFT 15 and the two electrodes 13 and 11 are formed, an insulating layer 57 having a flat surface is formed. In the case of the present embodiment, the insulating layer 57 is formed in the following manner.

A polyimide varnish (named Sun Ever 120 manufactured by Nissan Chemical Industries, Ltd. is used) is applied over the glass substrate 21 having formed thereon the TFT 15 and the two electrodes 13 and 11, by a spin coating method and this is dried for about one hour at a temperature of about 170°C. Note that a spin coating condition is set such that the film thickness of a portion of the polyimide varnish after being dried that corresponds to a flat portion of the glass substrate 21 is 4 $\mu$ m. When a polyimide varnish is applied over a step caused by the TFT 15 protruding from a substrate surface by the order of 2 $\mu$ m, on a deposition condition such as that described above, the step is reduced to 0.3 $\mu$ m at a polyimide varnish surface

**SHUSAKU YAMAMOTO**

and the protrusion manner thereof also becomes smooth. Note that the above-described polyimide varnish deposition condition should be determined taking into account the form of TFTs, etc., and the viscosity, etc., of a varnish to be used and thus is not limited to the condition used in the present embodiment. Furthermore, a material composing the insulating layer 57 is also not limited to a polyimide varnish used in the embodiment and other suitable materials can be used.

Next, the insulating layer 57 formed as described above is processed. The processing in the case of the present embodiment includes formation of a contact hole 53 in a region corresponding to a drain electrode of the TFT 15; exposure of part of the scanning and data electrodes from the insulating layer 57 to connect the scanning and data electrodes to a drive element separately prepared; and the like. The processing is performed by forming a resist mask using a normal photoetching technique and removing unnecessary portions of the insulating layer 57 using an etching solution and a rinse solution which are made specifically for Sun Ever manufactured by Nissan Chemical Industries, Ltd.

Then, on the insulating film 57, an ITO film is formed to a film thickness of about 1000Å by a suitable method such as an RF sputtering method, for example, and then, the ITO film is processed in a predetermined form (see FIG. 1(A)) by a photoetching technique to form pixel electrodes 51, whereby a pixel electrode substrate according to the present invention, such as that shown in FIGS. 1(A) and 1(B), is obtained.

On the other hand, the common electrode substrate which is already described using FIG. 2 is formed in the following

**SHUSAKU YAMAMOTO**

manner.

Color filters 33 are formed on a glass substrate 31 by a conventional known method. In this case too, a step of about  $2\mu\text{m}$  is formed between a surface of a color filter 33 and a substrate surface. As with when the pixel electrode substrate is formed, planarization is performed using Sun Ever 120 and on the same deposition condition, and unnecessary portions of the Sun Ever 120 are removed as with when the pixel electrode substrate is formed, to form an insulating layer 69. On the insulating layer 69, a common electrode 37 is formed by a conventional known method.

An alignment process is performed on the pixel electrode substrate and the common electrode substrate, which are formed as described above, and thereafter, these substrates are bonded together through spacers. After filling a liquid crystal in a gap between the substrates, a filling opening is sealed, whereby a liquid crystal display apparatus according to the present invention is obtained.

Note that the present invention is not limited to the above-described embodiment.

In the above-described embodiment, for a region that electrically separates pixel electrodes 51 in a direction orthogonal to the stripe direction of the data (source) electrodes, the region is not particularly formed above a scanning (gate) electrode and a conventional manner is taken. This is because unlike the data electrodes, the scanning electrodes are line-sequentially driven one by one and are besides driven at a considerably high speed from a point of view of a person viewing the liquid crystal display apparatus,



**SHUSAKU YAMAMOTO**

and thus, it cannot be considered much that the person viewing the liquid crystal display apparatus is aware of a domain phenomenon occurring on the scanning electrode side. However, it is, of course, possible to provide the separation region in the direction orthogonal to the stripe direction of the data electrodes and above a scanning (gate) electrode to shield a domain phenomenon occurring in this portion by the gate electrode.

Also, in the above-described embodiment, description is made using an example in which the switching elements are TFTs. However, it is obvious that the present invention can also be applied to a liquid crystal display apparatus in which switching elements are configured as other non-linear switching elements such as diodes or MIM (Metal Insulator Metal).

(Effects of the Invention)

As is also clear from the above description, a liquid crystal display apparatus of the present invention includes an insulating layer that planarizes steps caused by switching elements, etc., and includes pixel electrodes on the insulating layer. Therefore, a domain phenomenon is less likely to occur and air bubbles are less likely to be generated when filling a liquid crystal. Furthermore, since the occurrence of a domain phenomenon can be prevented without making a spacing between a pixel electrode and a source electrode linear, the flexibility of a pixel arrangement is not impaired.

Also, since an insulating layer can be provided to cover switching elements and source and gate electrodes, pixel electrodes can be formed all the way above regions where the source electrodes and the gate electrodes are formed. Hence,

**SHUSAKU YAMAMOTO**

an electrical separation region between pixel electrodes which is a region where a domain phenomenon is likely to occur is formed, for example, above a source electrode, whereby a domain phenomenon occurring due to a bend of an electric line of force can be shielded by the source electrode.

Accordingly, a liquid crystal display apparatus can be provided in which a domain phenomenon is less likely to occur and even when a domain phenomenon occurs the domain phenomenon is hard to be visually identified; therefore, in the liquid crystal display apparatus of the present invention, contrast characteristics and viewing angle characteristics are improved over conventional ones.

#### 4. Brief Description of the Drawings

FIGS. 1(A) and 1(B) are main part plan and cross-sectional views provided to describe a liquid crystal display apparatus of the present invention, and are a plan view and a cross-sectional view showing part of a pixel electrode substrate,

FIG. 2 is a main part cross-sectional view provided to describe the liquid crystal display apparatus of the present invention and is cross-sectional view showing part of a common electrode substrate,

FIGS. 3 to 5 are diagrams provided to describe a conventional liquid crystal display apparatus and FIG. 3 and 4 are a plan view and a cross-sectional view showing part of a pixel electrode substrate and FIG. 5 is a cross-sectional view showing part of the liquid crystal display apparatus, and FIG. 6 is a diagram provided to describe the conventional and

**SHUSAKU YAMAMOTO**

present invention.

11: Data Electrode (Source Electrode)

13: Scanning Electrode (Gate Electrode)

15: Switching Element

17: Drain Electrode

23: Gate Insulating Film

25: Amorphous Si

51, 51a, 51b: Pixel Electrode

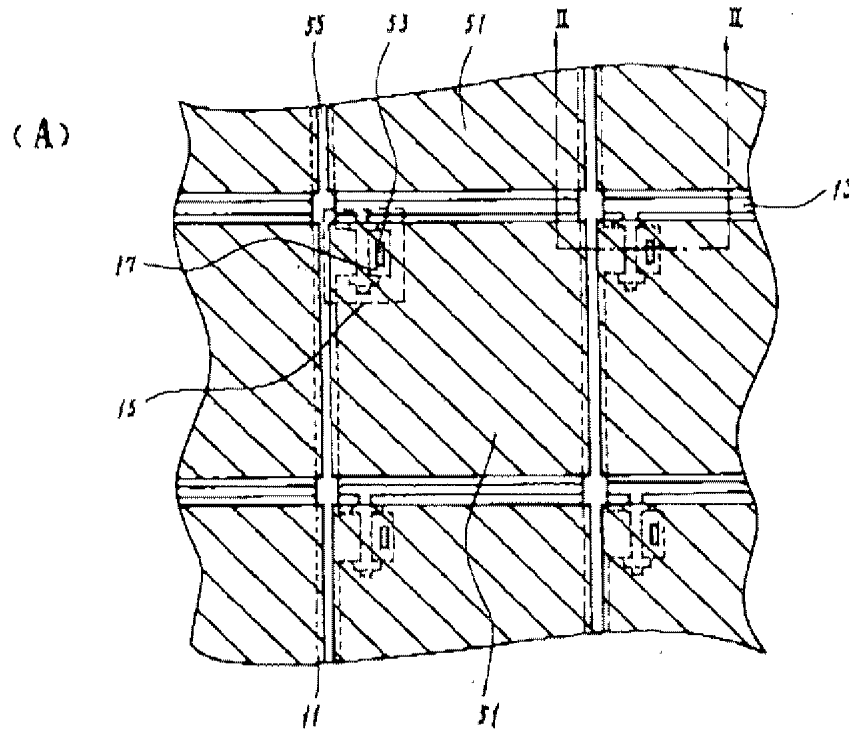
53: Contact Hole

55: Electrical Separation Region Between Pixel Electrodes

57, 61: Insulating Layer Having a Flat Surface

## SHUSAKU YAMAMOTO

[ FIG. 1(A) ]



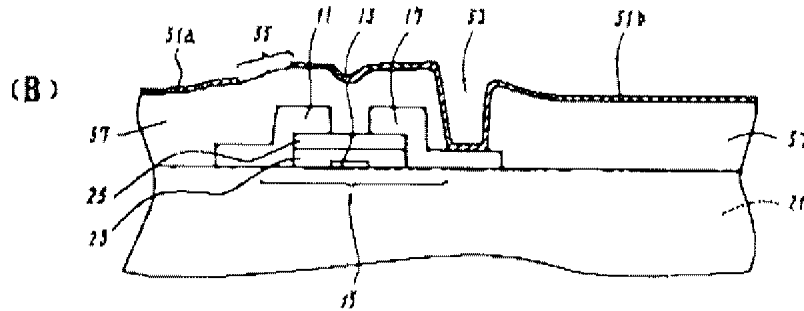
- |   |   |
|---|---|
| 11: DATA ELECTRODE (SOURCE ELECTRODE)   | 51: PIXEL ELECTRODE                                       |
| 13: SCANNING ELECTRODE (GATE ELECTRODE) | 53: CONTACT HOLE  |
| 15: SWITCHING ELEMENT (TFT)             | 55: ELECTRICAL SEPARATION REGION BETWEEN PIXEL ELECTRODES |
| 17: DRAIN ELECTRODE                     |   |

PLAN VIEW SHOWING PART OF A LIQUID CRYSTAL DISPLAY APPARATUS OF THE PRESENT INVENTION

FIG. 1

## SHUSAKU YAMAMOTO

[FIG. 1(B)]



23. GATE INSULATING FILM

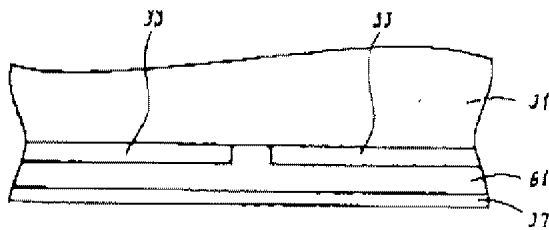
51a, 51b: PIXEL ELECTRODE

25. AMORPHOUS SI

57: INSULATING LAYER HAVING A  
FLAT SURFACECROSS-SECTIONAL VIEW SHOWING PART OF THE LIQUID  
CRYSTAL DISPLAY APPARATUS OF THE PRESENT INVENTION

FIG. 1

[FIG. 2]



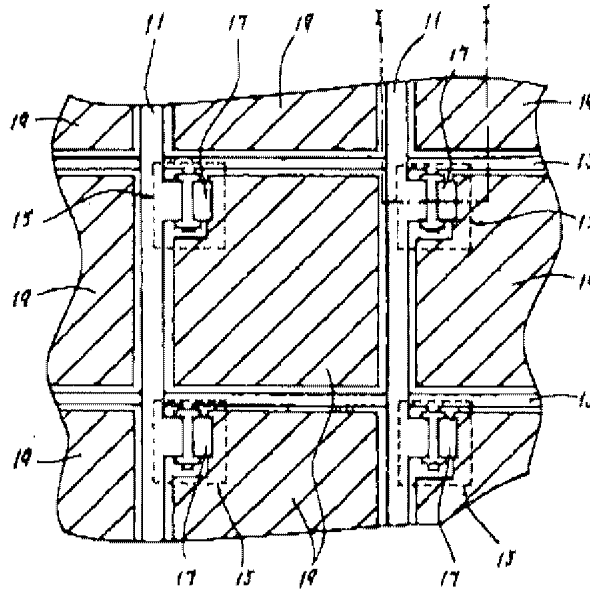
51. INSULATING LAYER HAVING A FLAT SURFACE

CROSS-SECTIONAL VIEW SHOWING PART OF  
THE LIQUID CRYSTAL DISPLAY APPARATUS  
OF THE PRESENT INVENTION

FIG. 2

## SHUSAKU YAMAMOTO

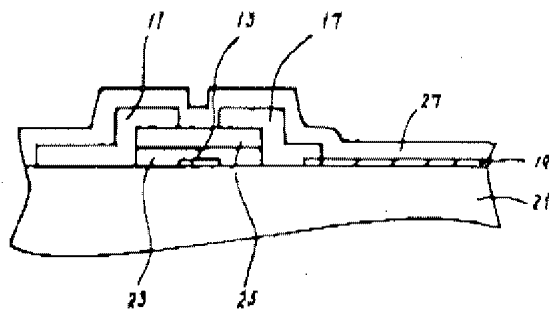
[FIG. 3]



PLAN VIEW PROVIDED TO DESCRIBE A  
CONVENTIONAL LIQUID CRYSTAL DISPLAY  
APPARATUS

FIG. 3

[FIG. 4]



CROSS-SECTIONAL VIEW PROVIDED TO DESCRIBE  
THE CONVENTIONAL LIQUID CRYSTAL DISPLAY  
APPARATUS

FIG. 4

SHUSAKU YAMAMOTO

[FIG. 5]

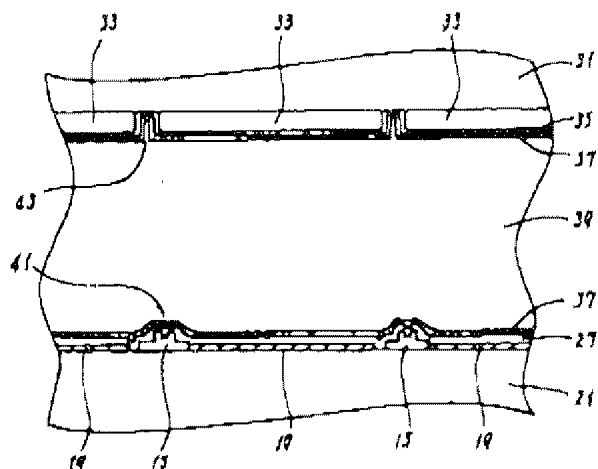


DIAGRAM PROVIDED TO DESCRIBE THE CONVENTIONAL  
LIQUID CRYSTAL DISPLAY APPARATUS

FIG. 5

[FIG. 6]

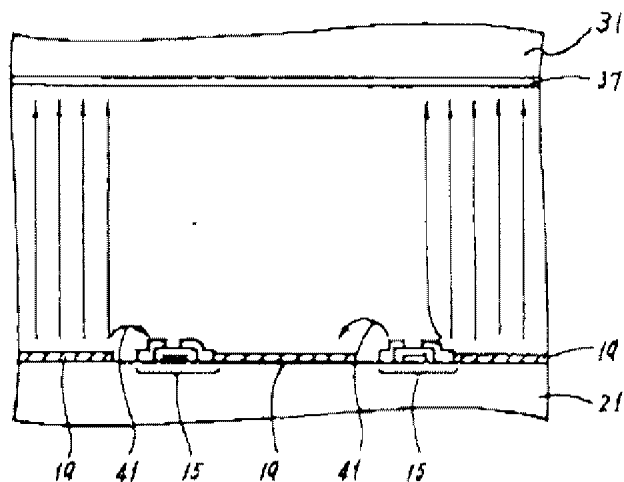


DIAGRAM PROVIDED TO DESCRIBE THE  
CONVENTIONAL AND THE PRESENT INVENTION

FIG. 6